Lamont-Doherty
Earth Observatory
of Columbia University

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FINAL REPORT - Grant N00014-94-1-0258

Sediment Acoustics

R. D. Stoll
Professor Emeritus and Special Research Scientist
Lamont-Doherty Earth Observatory of Columbia University

December 1, 2001

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK
OFFICE OF PROJECTS AND GRANTS

December 26, 2001
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Jeffrey Simmen
Technical representative
Office of Naval Research
Ballston Centre Tower One
800 North Quincy Street
Arlington, VA 22217-5660

Re: Award #N00014-94-1-0258 Final Report

Mr. Simmen:

We enclose two (2) copies of the final report for the above referenced award.

If you have any questions, please feel free to contact me at (212) 854-6851

Thank you for your support.

Sincerely,

Miranda Helly

Miranda Helly
Assistant Projects Officer

Enclosure

cc: Office of Naval Research Regional Office Boston
Office of Naval Research ONR 00CC
Defense Technical Information Center
Naval Research Laboratory

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Stoll, Robert D.

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This grant has funded work aimed primarily at developing a mathematical model to describe geoacoustic and seismic wave propagation in ocean sediments based on the knowledge of certain primitive variables such as porosity and grain-size distribution. The model is based on the classical Biot theory extended to take into account various mechanisms of energy loss that are known to be important in marine sediments. After the initial development of the model, a variety of field and lab experiments have been carried out to verify its predictions and help in the choice of various input parameters that are required.

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5. "SUBJECT INVENTIONS" REQUIRED TO BE REPORTED BY CONTRACTOR/SUBCONTRACTOR (If "None," so state)

NAME(S) OF INVENTOR(S) (Last, First, Middle Initial) a.	TITLE OF INVENTION(S) b.	DISCLOSURE NUMBER, PATENT APPLICATION SERIAL NUMBER OR PATENT NUMBER c.	ELECTION TO FILE PATENT APPLICATIONS (X) d.				CONFIRMATORY INSTRUMENT OR ASSIGNMENT FORWARDED TO CONTRACTING OFFICER (X) e.	
			(1) UNITED STATES		(2) FOREIGN			
			(a) YES	(b) NO	(a) YES	(b) NO	(a) YES	(b) NO
Stoll, Robert D. Akal, T.	Probe for Evaluating Seafloor Geoacoustic and Geitechnical Properties	5,681,982						

f. EMPLOYER OF INVENTOR(S) NOT EMPLOYED BY CONTRACTOR/SUBCONTRACTOR		g. ELECTED FOREIGN COUNTRIES IN WHICH A PATENT APPLICATION WILL BE FILED	
(1) (a) NAME OF INVENTOR (Last, First, Middle Initial) Akal, T.	(2) (a) NAME OF INVENTOR (Last, First, Middle Initial)	(1) TITLE OF INVENTION	(2) FOREIGN COUNTRIES OF PATENT APPLICATION
(b) NAME OF EMPLOYER NATO, Saclant Undersea Research Ctr.	(b) NAME OF EMPLOYER		
(c) ADDRESS OF EMPLOYER (Include ZIP Code) Viale S. Bartolomeo 400, 19138 LaSpezia, ITALY	(c) ADDRESS OF EMPLOYER (Include ZIP Code)		

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6. SUBCONTRACTS AWARDED BY CONTRACTOR/SUBCONTRACTOR (If "None," so state)

NAME OF SUBCONTRACTOR(S) a.	ADDRESS (Include ZIP Code) b.	SUBCONTRACT NUMBER(S) c.	FAR "PATENT RIGHTS" d.		DESCRIPTION OF WORK TO BE PERFORMED UNDER SUBCONTRACT(S) e.	SUBCONTRACT DATES (YYYYMMDD) f.	
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7. CERTIFICATION OF REPORT BY CONTRACTOR/SUBCONTRACTOR (Not required if: (X as appropriate)) [ ] SMALL BUSINESS or [ ] NONPROFIT ORGANIZATION

I certify that the reporting party has procedures for prompt identification and timely disclosure of "Subject Inventions," that such procedures have been followed and that all "Subject Inventions" have been reported.

a. NAME OF AUTHORIZED CONTRACTOR/SUBCONTRACTOR OFFICIAL (Last, First, Middle Initial)	b. TITLE	c. SIGNATURE	d. DATE SIGNED
Stoll, Robert D.	Principal Investigator	Robert D. Stoll	18 December, 2001

FINAL REPORT - Grant N00014-94-1-0258

Sediment Acoustics

R. D. Stoll
Professor Emeritus and Special Research Scientist
Lamont-Doherty Earth Observatory of Columbia University

December 1, 2001

Abstract:

This grant has funded work aimed primarily at developing a mathematical model to describe geoacoustic and seismic wave propagation in ocean sediments based on the knowledge of certain primitive variables such as porosity and grain-size distribution. The model is based on the classical Biot theory extended to take into account various mechanisms of energy loss that are known to be important in marine sediments. After the initial development of the model, a variety of field and lab experiments have been carried out to verify its predictions and help in the choice of various input parameters that are required.

Introduction:

The long-term goal of our work in sediment acoustics has been to develop a physically meaningful model to describe geoacoustic wave propagation in marine sediments on the basis of a set of primitive physical variables.The principal scientific objective has been to develop a mathematical model that is able to predict wave velocity and attenuation in the sediments found near the seafloor. Specifically, the model has been designed to accept as input parameters certain fundamental primitive variables, such as grain size, porosity, grain density and gas content that are directly related to the geological processes producing the wide range of sediments that are encountered in the world's oceans. A number of auxiliary technological objectives have also arisen in the course of our work related to remote sensing and in-situ measurement of sediment geoacoustic properties. One of these objectives has been to develop a set of tools that allow the measurement of velocity and attenuation as well as certain related geotechnical variables such as shear strength and cone penetration resistance in the sediment column. These measurements provide the "ground truth" for assessing the validity and usefulness of the basic geoacoustic model and have important applications in other areas such as mine burial prediction and the evaluation of sonar records..

Approach:

Our approach has been to develop a theoretical geoacoustic model based on the classical Biot theory for porous, fluid-filled media. The model reflects the influence of variables such as porosity and overburden pressure and includes several kinds of intrinsic attenuation that are important in different kinds of ocean sediment. We have performed extensive field and laboratory experiments aimed at determining appropriate input parameters as well as checking the validity of

the model predictions. Much of our earlier work is described in the monograph "Sediment Acoustics" (Stoll, 1989). More recent progress, especially the results of extensive field work, has been described in a series of technical papers and is being incorporated into several new chapters in a second edition of the monograph to be published in the near future. Over the past several years we have participated in a number of field experiments in cooperation with other investigators such as T. Akal at SACLANT Undersea Research Center in LaSpezia, Italy and M. Richardson at the Naval Research Laboratory, Stennis Space Center. During this work several new testing techniques were developed to measure in-situ properties of the sediments immediately beneath the seafloor including p-wave velocity and attenuation, shear wave velocity and attenuation for both vertically and horizontally polarized wave motion, and undrained shear strength based on quasistatic cone penetration tests. In addition, sediment cores taken at many sites were analyzed to obtain porosity, grain size distribution and other fundamental properties, the objective being to establish the ground truth at each test location and develop correlations between such quantities as in-situ shear wave velocity, undrained shear strength and porosity.

In addition to the field work mentioned above, a new series of laboratory experiments has been initiated for the purpose of studying the dispersion that occurs during p-wave propagation in granular sediments as one moves from the "low frequency" regime to the "high frequency" range that is currently of considerable interest. The purpose of this work is to help in the evaluation of some of the new propagation models that are being proposed to explain the penetration of acoustic energy into the seafloor at low grazing angles observed in recent experiments. Some of these new models that are based largely on high frequency data, and in some cases idealized scattering models, do not properly account for the dispersion that would normally be expected in going from low to high frequencies and therefore may be questionable for applications in the general case.

The work carried out under this grant has been described in a series of technical papers that are listed in the reference list given below. These papers together with the monograph "Sediment Acoustics" by R. D. Stoll published by Springer Verlag in 1990 constitute a complete record of our progress in work under the Grant.

Referrences (covering work totally or partially supported by Grant):

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